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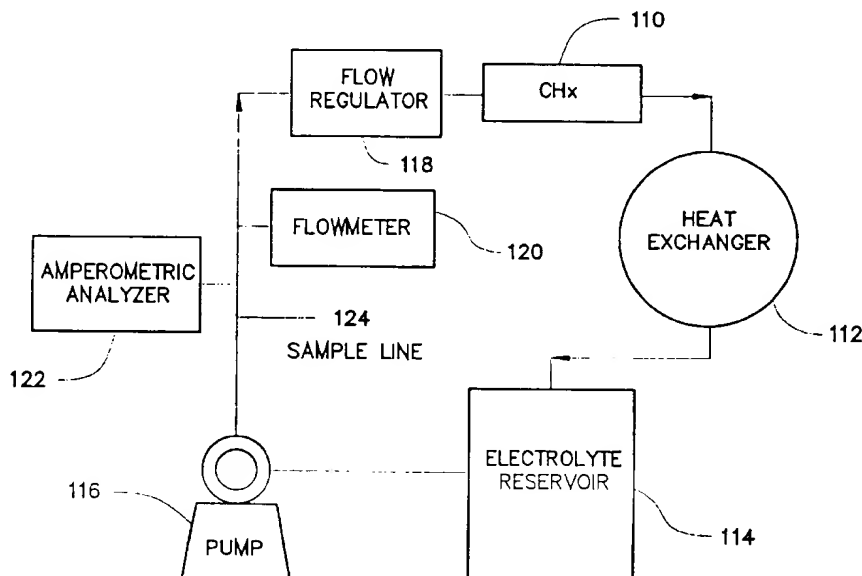
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(54) Title: CORROSION CONTROL UTILIZING A HYDROGEN PEROXIDE DONOR



(57) Abstract: The present invention describes an innovative means of inhibiting corrosion of metals which experience active-passive transition in contact with an electrolyte. This invention incorporates hydrogen peroxide and/or peroxycarboxylic acids or their constituents to inhibit corrosion by inducing passivation of the metal. Application of this technology reduces the potential for fouling, scaling and deposition as well as outperforming existing methods of corrosion control in these applications.

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CORROSION CONTROL UTILIZING A HYDROGEN PEROXIDE DONORFIELD OF THE INVENTION

This invention relates to a method of inhibiting corrosion as well as inhibiting scale and deposit formation resulting from the saturation of mineral salts, and buildup of corrosion byproducts. The invention generally relates to the inhibition of corrosion of metals in contact with an electrolyte and the reduction of insulating films owing to scale formation/deposition. The invention most particularly relates to the inhibition of corrosion on metals which experience active-passive transition by application of a hydrogen peroxide donor. Illustrative of such metals are steel(s), aluminum, titanium or mixtures thereof; however the instant invention contemplates the treatment of any metal which is capable of experiencing active/passive transitions when exposed to passivating agents.

BACKGROUND OF THE INVENTION

Corrosion of metals, particularly those metals found in cooling water circulating systems, and most particularly those in heat exchangers, are of critical concern.

In industrial cooling systems, water from rivers, lakes, ponds, wells, wastewater treatment plant effluent etc., is employed as the cooling media for heat exchangers. Such waters can contain a variety of either dissolved and/or suspended materials such as mineral salts, metals, organics, silt, mud etc.

The cooling water from a heat exchanger is typically passed through a cooling tower, spray pond or evaporative system prior to discharge or reuse. In such systems, cooling is achieved by evaporating a portion of the water passing through the system. Because of the evaporation

1 that takes place during the cooling, both dissolved and
2 suspended solids concentrate. The concentrating of
3 various anionic ions such as chlorides and sulfates can
4 increase the rate of corrosion of the metals making up the
5 cooling system. This is especially true with the metals
6 making up the heat exchangers that are experiencing higher
7 temperatures.

8 Furthermore, contaminants such as hydrogen sulfide
9 can also increase corrosion rates. Likewise, mineral
10 salts, for example those of calcium and magnesium can
11 induce scaling of the heat exchanger. A scale common in
12 cooling systems is calcium carbonate. Other scales or
13 deposits such as calcium phosphate or iron can also
14 inhibit heat transfer as well as induce under-deposit
15 corrosion.

16 Deposit formation on heat exchangers seriously
17 reduces heat transfer. Corrosion byproducts can form on
18 the metal surface where a corrosion cell has formed.
19 Deposits from metal oxides, silt, mud, microbiological
20 activity, and process contamination can reduce the
21 efficiency of heat transfer as well as increase corrosion.

22 Reducing the corrosion, scaling and deposition of
23 heat exchangers and associated cooling system equipment is
24 thus essential to the efficient and economical operation
25 of a cooling water system. Excessive corrosion of the
26 metallic surfaces can cause the premature failure of
27 process equipment, necessitating down time for the
28 replacement or repair of the equipment. Additionally, the
29 buildup of corrosion products on the heat transfer
30 surfaces impedes water flow and reduces heat transfer
31 efficiency thereby limiting production or requiring
32 downtime for cleaning.

33 Aspects of Corrosion

34 In order for corrosion to occur, a corrosion cell
35 must form. The corrosion cell consist of two half cells,

1 the cathode, and the anode.

2 The cathode is defined as the point where the
3 reduction of a reducible substance takes place. In waters
4 where the pH is greater than 4.2 (like that of a cooling
5 water system), the primary reducible substance is oxygen.
6 The steps involved with the cathode include: oxygen
7 diffusion to the metal surface, adsorb by either physical
8 or chemical adsorption, electron transfer, rearrangement
9 with other adsorbed materials (i.e. water and electrons
10 with subsequent formation of hydroxide ions), de-sorption
11 of the newly formed byproduct (hydroxide), and diffusion
12 into the bulk meter. With increased concentration of
13 hydroxide ions, oxygen diffusion and adsorption rates are
14 reduced.

15 The anode is defined as the point where dissolution
16 of metal ions occurs. The dissolution of metal ions at
17 the anode is a chemical process. The reaction forms
18 ferrous hydroxide. Initially, the potential at the anode
19 is low; however with time, the electrical potential at the
20 anode increases. The increased potential is the result of
21 the increased concentration of metal ions (result of
22 dissolution) in the immediate vicinity of the anode. The
23 increased concentration of metal ions induces the
24 formation of a Metal Ion Concentration Cell, as well as
25 the reduction of oxygen. The increasing concentration of
26 cationic charged ions at the anode increases the
27 electrical potential of the anode.

28 General corrosion is defined as a state where the
29 potential of the cathode decreases with time while the
30 potential at the anode increases. At some point, the
31 potentials of the cathode and anode shift or find
32 neighboring electrodes of stronger or weaker potential.
33 This shifting or jumping is the result of the mechanisms
34 already described. As the hydroxide concentration at the
35 cathode increases, oxygen adsorption decreases, and the

1 cathodes potential goes down. At the anode, where the
2 concentration of cationic ions increases, the demand for
3 electrons increases, so the potential goes up. This
4 process of electrode reversal continues across the surface
5 of the metal resulting in a uniform loss of metal.

6 Pitting corrosion refers to a condition where the
7 potential surrounding the anode is high (cathodic) and
8 electron flow is not distributed across many anodes,
9 therefore the electron comes from a local anode. Pitting
10 corrosion is of great concern because of the high loss of
11 metal from a localized area. At a metal loss rate of
12 several mils per year (MPY), general corrosion would take
13 many decades of continued corrosion before resulting in
14 failure of the part, e.g. of a heat exchanger. However,
15 in pitting corrosion, the electron flow and subsequent
16 metal loss is from a localized area. Pitting corrosion
17 often results in equipment failure long before reaching
18 the expected life of the equipment, e.g. the heat
19 exchanger.

20 Pitting corrosion occurs when the cathodic surface
21 has been depolarized. Chlorides for example, compete for
22 the metal surface with the oxygen donor. When a chloride
23 ion is adsorbed at the metal surface, it prevents the
24 oxygen from reaching the surface. The potential at the
25 site is reduced, and the area becomes anodic. This induces
26 a high flux of electrons to flow from the localized site
27 to the surrounding cathode.

28 Passivation can be defined as the loss of chemical
29 reactivity exhibited by certain metals and alloys under
30 specific environmental conditions. The onset of
31 passivation is associated with the formation of an oxide
32 layer that is resistant to further oxidation.

33 The mechanism of passivation, as it relates to
34 ferrous metal surfaces, involves the dissolution of metal
35 ions, followed by formation of a ferrous hydroxide layer,

1 followed by conversion to an insoluble ferric oxide by
2 reaction with oxygen. Analysis of passive films indicates
3 a layered structure with an outer layer of gamma iron
4 oxide and an inner layer of magnetite.

5 Passivation occurs when we have established
6 sufficient oxidation potential. At low oxidation
7 potential, insufficient concentrations of oxidizer exist
8 to establish a homogenous oxide layer; distinct anodes
9 and cathodes exist. When sufficient oxidizer is present,
10 the electrical potential of the entire surface is
11 increased. The concentration of oxidizer is sufficient to
12 induce the "flash" formation of an oxide layer. In other
13 words, the oxidizer concentration is sufficiently high to
14 react with the ferrous hydroxide across the entire metal
15 surface. With increased oxidation potential, the current
16 density increases. The current density required to induce
17 passivation is called the critical current. At yet higher
18 oxidizer concentrations, aggressive attack of the oxide
19 layer occurs, and the corrosion rates increase; this is
20 termed the transpassive region.

21 Passivation is a process requiring oxygen. Therefore,
22 inhibitors that induce passivation must increase the
23 oxidizing potential or make better use of the oxidizer
24 present.

25 Inhibitors such as chromate, nitrite and hydroxide
26 raise the oxidizing potential of the solution by directly
27 supplying oxygen to the anode to react with the metal ions
28 thereby reducing the formation of a metal oxide. For this
29 reason, these inhibitors can be used in solutions without
30 oxygen present. These oxidizing inhibitors are involved
31 with direct oxidation of the ferrous hydroxide to ferric
32 oxides.

33 Inhibitors such as phosphate, silicate, borate and
34 molybdate are non-oxidizing inhibitors which form
35 complexes with iron (III) species so as to stabilize them

1 from disproportionation (the transformation of a substance
2 into two or more substances by oxidation or reduction) to
3 the more soluble Fe (II) species until reaction with
4 dissolved oxygen creates the more immune oxides. These
5 inhibitors do require the presence of oxygen to promote
6 passivation. Their performance can be enhanced with the
7 addition of a peroxide compound where peroxide is used to
8 enhance the formation of a passive oxide film.

9 Anodic inhibition is desired from an operational
10 viewpoint since the oxide film is very thin, and the
11 corrosion rates are lower than that achieved by cathodic
12 inhibition. However, the potential drawback is that if
13 the film breaks are not repaired, due to insufficient
14 inhibitor concentrations for example, rapid pitting may
15 occur. This is the result of the fact that the cathodic
16 reaction can occur all over the passive surface, but the
17 anodic reaction (metal dissolution) can only occur at
18 broken film sites.

19 Chromate treatments have been long recognized as the
20 standard to compare other treatment programs. Chromates,
21 induce the formation of a uniform oxide film thereby
22 inducing passivation of the metal surface.

23 While chromate programs could be run at higher pH
24 many were operated at lower pH (6.5 - 7.5). This
25 significantly lowered the potential for scale formation.

26 Chromate technology has been eliminated from most
27 applications involving cooling water treatment due to the
28 environmental and human health hazards. Since the
29 elimination of chromates, the most common treatment
30 methodologies now incorporate technologies that increase
31 scale and fouling potential.

32 Anodic phosphate treatments require levels of
33 phosphate exceeding those allowed by the natural
34 solubility of phosphate when in the presence of calcium.
35 To stabilize phosphates and inhibit scale formation,

1 polymers that stabilize the formation of calcium phosphate
2 salts are applied. Also, in some areas, lower phosphate
3 levels are required to meet environmental restrictions.

4 Low phosphate levels can be achieved by incorporating
5 a cathodic inhibitor like zinc. Zinc is a cathodic
6 inhibitor that precipitates at the cathode by forming zinc
7 hydroxide. Concentrations of peroxide and
8 peroxy-carboxylic acids can be reduced with the addition of
9 a cathodic inhibitor such as zinc.

10 Again, because of the limited solubility of zinc,
11 polymers are commonly fed to help prevent fouling from
12 precipitation. Also, in many areas, zinc has environmental
13 implications.

14 Using existing treatment methods, operating cost
15 increased, and in many operating conditions such as high
16 heat flux and/or high chlorides, results are less than
17 desirable.

18 Thus, what is needed in the industry is a treatment
19 program that is effective at inhibiting corrosion -under
20 various heat flux and water chemistry conditions, as well
21 as being environmentally innocuous.

22

23 DESCRIPTION OF THE PRIOR ART

24 US Patent No. 5,800,732 describes the use of hydrogen
25 peroxide as a means of controlling microbial activity in
26 an all-in-one treatment for cooling water.

27 US Patent No. 4,977,292 describes the development of an
28 organic phosphorous compound using hydrogen peroxide as an
29 oxidizer to initiate the oxidation reaction.

30 US Patent No. 5,382,367 describes the use of hydrogen
31 peroxide in cooling water systems to control
32 microbiological activity in said systems.

33 US Patent Nos. 5,980,758, 5,785,867, 5,658,467 and
34 5,494,588 describe the use of peracetic acid with non-
35 oxidizing biocides to inhibit growth of microorganisms.

1 The prior art fails to describe the use of peroxide
2 and/or peroxycarboxylic acids as standalone corrosion
3 inhibitors, much less passivating agents, for cooling
4 water treatment. Furthermore, no prior art reference
5 describes the use of these compounds as on-line deposit
6 control and deposit removal agents for said application.

7
8 SUMMARY OF THE INVENTION

9 The instant invention is directed toward a method
10 which provides superior corrosion inhibition, particularly
11 to those areas experiencing heat transfer; namely the heat
12 exchangers where corrosion and scale potential is most
13 prevalent. The instant process recognizes the fact that
14 both hydrogen peroxide and peroxycarboxylic acids are
15 strong oxidizing agents having important similarities to
16 chromate (VI) in that they are anionic oxidizers.

17 Since they function as anionic oxidizers, these
18 compounds have high solubility in water and readily
19 diffuse to the metal surface. Being strong oxidizers as
20 well as oxygen donors, they are able to directly supply
21 the oxygen needed to induce passivation.

22 The instant process utilizes these compounds as
23 corrosion inhibitors and passivators to achieve
24 performance equal to or exceeding that obtained by
25 chromate. Such performance has been demonstrated under
26 high heat load conditions and/or in the presence of
27 corrosion inducing ions such as chlorides. These
28 compounds also provide an environmentally innocuous
29 treatment that eliminates the need for other corrosion
30 inhibitors such as zinc and phosphate based treatments, as
31 well as their supporting polymer treatment. The instant
32 invention teaches an innovative treatment technology
33 having application wherever removal of scale or deposits
34 in contact with an electrolyte is required. The invention
35 also teaches effective removal of insulating films while

1 inhibiting corrosion (especially under heat transfer) and
2 can be effectively used to improve operational performance
3 without suffering loss of system integrity or production
4 time.

5 The chemistry selected for removal of the insulating
6 layers is based on the composition of the deposits. In the
7 test, ferrous oxide was the primary composition and
8 therefore, peroxydic acid solution or mineral acid was
9 affective at removing the deposit. Other chelating,
10 sequestering, and dispersing agents could also provide
11 effective results when used in conjunction with
12 peroxydic acid(s) solutions.

13 Accordingly, it is an objective of the instant
14 invention to utilize hydrogen peroxide donors as corrosion
15 inhibitors and passivators to achieve performance equal to
16 or exceeding that obtained by chromate .

17 It is a further objective of the instant invention to
18 provide an environmentally innocuous treatment that
19 eliminates the need for other corrosion inhibitors such as
20 zinc and phosphate based treatments, as well as their
21 supporting polymer treatment.

22 It is yet another objective of the instant invention
23 to teach a treatment technology having application
24 wherever removal of scale or deposits in contact with an
25 electrolyte is required.

26 It is a still further objective of the invention to
27 teach effective removal of insulating films while
28 inhibiting corrosion (especially under heat transfer)
29 thereby improving operational performance without
30 suffering loss of system integrity or production time.

31 Other objects and advantages of this invention will
32 become apparent from the following description taken in
33 conjunction with the accompanying drawings wherein are set
34 forth, by way of illustration and example, certain
35 embodiments of this invention. The drawings constitute a

1 part of this specification and include exemplary
2 embodiments of the present invention and illustrate
3 various objects and features thereof.
4

5 BRIEF DESCRIPTION OF THE FIGURES

6 Figure 1 is illustrative of a circulating system useful
7 for conducting tests replicating a typical cooling water
8 treatment application;

9 Figure 2 illustrates a cross-sectional view of a MENTOR
10 CHx device;

11 Figure 3 is a graphical representation of Electro Chemical
12 Noise (ECN) in the presence of Chromate;

13 Figure 4 is a graphical representation of ECN in the
14 presence of Hydrogen Peroxide;

15 Figure 5 is a graphical representation of ECN in the
16 presence of Peroxide-Citric Acid;

17 Figure 6 is a graphical representation of Heat Transfer
18 During Cleaning ;

19 Figure 7 is a graphical representation of ECN During
20 Cleaning;

21 Figure 8 is a graphical representation of Activity Factor
22 (AF) During Cleaning.
23

24 DETAILED DESCRIPTION OF THE INVENTION

25 In accordance with Figure 1, a system was developed
26 incorporating the use of a heated metal element, sensors
27 for monitoring electrochemical noise corrosion, linear
28 polarization, and heat transfer efficiency. Figure 1 is
29 illustrative of a circulating system useful for conducting
30 tests replicating a typical cooling water treatment
31 application. Specifically, the instant device is
32 comprised of a system that incorporates: a MENTOR CHx heat
33 transfer device (more particularly described in Figure 2)
34 110 that is made of the metallurgy to be tested. The
35 metallurgy under heat transfer is in contact with an

1 electrolyte which is pumped via pump 116 through a heat
2 exchanger 112 through which electrolyte from electrolyte
3 reservoir 114 is passed. The electrolyte flow rates and
4 rates of heat transfer are adjusted to desired levels by
5 adjusting flow regulator 118. A flowmeter 120 is in fluid
6 communication for ease of adjustments. If added, the
7 concentration of a passivator is measured using a
8 standardized amperometric analyzer. A sample line 124 is
9 optionally provided for convenience in withdrawing samples
10 for testing.

11 Now with further reference to Figure 2, a block 210
12 is comprised of a series of pieces of the desired
13 metallurgy 212 that are joined with an insulating material
14 214 placed between each adjoining piece. This series of
15 adjoined pieces will be designated the "block". A hole
16 (not shown) is incorporated at some part of the
17 construction process through which the electrolyte will
18 contact the block. The metal pieces making up the block
19 are equipped with appropriate sensing apparatus (not
20 shown) for the sensing of ECN and LPR. Other sensing
21 apparatus for determination of temperature gradients, heat
22 transfer coefficients, etc. can be applied in a way that
23 does not interfere with the performance of ECN and LPR
24 sensing apparatus. The block is equipped with a device
25 216 to provide heat thru the block. The block is combined
26 with other supporting equipment necessary for replicating
27 the operational environment of the heat transfer equipment
28 in question. This can include, but is not limited to,
29 equipment necessary for replicating electrolyte flow rate,
30 electrolyte chemical parameters, and skin temperature at
31 the heat exchanger electrolyte interface, etc.

32 The process control parameters are adjusted and
33 controlled to replicate the operational environment at the
34 heat exchanger metal-electrolyte interface. The heated
35 element was made of 1010 carbon steel. A circulation pump

1 was attached to a reservoir pump the water of desired
2 chemistry through the testing element, a cooling coil and
3 back to the reservoir.

4 The chemistry selected for removal of the insulating
5 layers is based on the composition of the deposits.
6 Therefore, in the following tests, since ferrous oxide was
7 the primary composition, a peroxycitric acid solution or
8 mineral acid was chosen for effectively removing the
9 deposit. Other chelating, sequestering, and dispersing
10 agents could also provide effective results when used in
11 conjunction with peroxycarboxylic acid(s) solutions.

12 Water was prepared having the following chemical
13 characteristics:

14 Calcium as CaCO_3 = 110 ppm

15 Total Alkalinity as CaCO_3 = 66 ppm

16 Chloride as Cl^- = 25 ppm

17 pH = 7.9

18 The 1010 carbon steel block temperature was set to
19 152°F which achieved a calculated skin temperature of
20 144°F. Flow rate through the CHx was set at 3.8gpm which
21 equates to a velocity of 4ft/sec. Steady state conditions
22 were achieved and held during testing.

23 EXAMPLES:

24 Baseline - Chromate Test

25 Baseline data for chromate treatment was achieved using
26 laboratory grade sodium chromate. Initially the system was
27 treated with levels 4 times (1600 ppm) the normal
28 concentration of chromate (as CrO_4) to induce passivation.
29 After 2 hours of circulation under heat transfer, some of
30 the water was removed while it was replaced with identical
31 quality makeup water without the chromate. The operating
32 pH stabilized at 7.7 by the addition of the H_2SO_4 . This
33 dilution continued until the chromate level dropped to the
34 test concentration of (330 ppm). The system was allowed to
35 operate under steady state conditions to determine

1 corrosion rates under the described conditions as depicted
2 in Figure 5.

3 Peroxide Test

4 The system was allowed to circulate under heat transfer
5 until it reached steady state. The water was treated with
6 hydrogen peroxide to achieve an initial dosage of 200ppm.
7 The pH of the solution was adjusted to 7.4 by the addition
8 of H_2SO_4 . After reaching steady state, the ECN was
9 monitored and recorded as illustrated in Figure 4. The
10 system was then flushed until peroxide was undetectable
11 and the pH of the circulating water equaled the flush
12 water.

13 Figure 4 utilized the same water chemistry and heat
14 load conditions as in Figure 3, using hydrogen peroxide as
15 the corrosion inhibitor.

16 The comparative results clearly indicate the improved
17 corrosion inhibitor capability of the peroxide based
18 treatment.

19 Peroxydicarboxylic Acid Test

20 Peroxydicarboxylic acids are formed from acids selected
21 from the group consisting of formic acid, acetic acid,
22 citric acid, oxalic acid, gluconic acid, glucoheptonic
23 acid, succinic acid, acrylic acid, polyacrylic acid,
24 maleic acid, polymaleic acid, polyepoxysuccinic acid,
25 ethylene-diamine-tetraacetic acid, malonic acid, adipic
26 acid, phosphonobutanepolycarboxylic acid and mixtures
27 thereof. As exemplified herein, peroxydicitric acid is
28 an equilibrium product of hydrogen peroxide and citric
29 acid (a "solution" of a peroxydicarboxylic acid is comprised
30 of the peroxydicarboxylic acid, hydrogen peroxide and the
31 carboxylic acid). A solution of peroxydicitric acid was
32 prepared by combining a solution of citric acid, with 30%
33 laboratory grade hydrogen peroxide. The ratio of the blend
34 was 2:1 hydrogen peroxide to citric acid based on actives.

35 After flushing the system, 130ppm of the blend was

1 added to the water. The pH was measured at 6.8. After
2 allowing the system to reach steady state, the ECN
3 corrosion rate was monitored and recorded as illustrated
4 in Figure 5.

5 The results illustrate that hydrogen peroxide and
6 peroxy-carboxylic acids (and/or respective constituents
7 thereof) provide superior corrosion inhibition compared to
8 the long established industry standard chromate based
9 treatment technology.

10 Cleaning Test

11 To achieve a skin temperature of 144°F, the CHx
12 required $65.6412 \text{ BTU/hr.ft}^2 \times 10^3$. This was recorded as the
13 baseline heat transfer under steady state conditions. The
14 CHx was then exposed to a corrosive electrolyte under
15 stagnant conditions for several days.

16 When the circulation pump was activated, red water
17 was observed leaving the CHx. After allowing the system to
18 reach steady state under heat transfer, the rate of heat
19 transfer required to achieve a skin temperature of 144°F
20 was monitored and recorded as $52.8664 \text{ BTU/hr.ft}^2 \times 10^3$.

21 The lower heat transfer value indicates a 19.46%
22 reduction in heat transfer efficiency due to the presence
23 of corrosion byproducts (ferric oxide).

24 The electrolyte was initially treated with 1000ppm of
25 a peroxycitric acid solution made from a 2:1 actives
26 weight ratio of hydrogen peroxide and citric acid. Figure
27 6 illustrates the heat transfer increased (data point 4)
28 while ECN (Figure 7) showed a corresponding rise in
29 corrosion rate. ECN corrosion rates then dramatically drop
30 (data point 5), followed by the onset of a passive-steady
31 state condition (data points 8-13).

32 By data point 12 (Fig. 6), heat transfer recovered
33 22% of the lost heat transfer resulting from the removal
34 of much of the insulating ferric oxide.

35

1 Data point 13 shows the affects of adding 1000ppm of
2 HCl (based on active(s)). Heat transfer is completely
3 restored while maintaining unprecedented control of ECN
4 corrosion rate and Activity Factor (Figure 8). The
5 "Activity Factor" (AF) is calculated using the equation:

6
$$AF = \sigma_i / i_{rms}$$

7 where σ_i is the standard deviation of the electrochemical
8 current noise data, and i_{rms} is the root mean square of
9 the electrochemical current noise. The AF detects changes
10 in current and highlights the deviation from the steady
11 state condition.

12 Test results clearly illustrate the cleaning and
13 corrosion inhibition capabilities of peroxycarboxylic acid
14 solutions. Even in the presence of high chlorides and low
15 pH (~4.0), pitting corrosion was averted, and corrosion
16 rates were controlled while regaining 100% efficiency.

17 This technology can also be utilized in conjunction
18 with other corrosion inhibitors to improve their
19 performance. Examples of such other corrosion inhibitors
20 include but are not limited to orthophosphates,
21 polyphosphates, phosphonates, zinc and azoles. It is
22 further understood that the instant treatment technology
23 could, and in many cases would be utilized with other
24 water treatments such as deposit control agents, corrosion
25 inhibitors and microbiological control agents.

26 It is to be understood that while a certain form of
27 the invention is illustrated, it is not to be limited to
28 the specific form or arrangement of parts herein described
29 and shown. It will be apparent to those skilled in the
30 art that various changes may be made without departing
31 from the scope of the invention and the invention is not
32 to be considered limited to what is shown and described in
33 the specification and drawings.

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CLAIMS

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What is claimed is:

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Claim 1. A method for inhibition of corrosion of a metal which experiences active-passive transition in contact with an electrolyte comprising:

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incorporating one or more hydrogen peroxide donors with said electrolyte at a concentration effective to inhibit corrosion.

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Claim 2. The method in accordance with claim 1 wherein said hydrogen peroxide donors are selected from the group consisting of hydrogen peroxide, sodium peroxide, potassium peroxide, calcium dioxide, sodium percarbonate, potassium percarbonate, sodium perborate, potassium perborate or mixtures thereof.

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23

Claim 3. The method in accordance with claim 1 wherein said metal is selected from the group consisting of steel(s), aluminum, titanium or mixtures thereof.

24

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26

Claim 4. A method for inhibition of corrosion of a metal which experiences active-passive transition in contact with an electrolyte comprising:

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28

29

incorporating one or more peroxycarboxylic acid or constituents thereof with said electrolyte at a concentration effective to inhibit corrosion.

1 Claim 5. The method in accordance with claim 4
2 wherein said metal is selected from the group consisting
3 of steel(s), aluminum, titanium or mixtures thereof.
4

5 Claim 6. The method in accordance with claim 4
6 wherein said peroxy-carboxylic acids are formed from acids
7 selected from the group consisting of formic acid, acetic
8 acid, citric acid, oxalic acid, gluconic acid,
9 glucoheptonic acid, succinic acid, acrylic acid,
10 polyacrylic acid, maleic acid, polymaleic acid,
11 polyepoxysuccinic acid, ethylene-diamine-tetraacetic acid,
12 malonic acid, adipic acid, phosphonobutanepolycarboxylic
13 acid and mixtures thereof.
14

15 Claim 7. A method of inhibition of corrosion during
16 removal of deposits from a metal which experiences active-
17 passive transition while in contact with an electrolyte
18 comprising:

19 incorporating one or more peroxy-carboxylic acids or
20 their constituents with said electrolyte at a
21 concentration effective to inhibit corrosion.
22

23 Claim 8. The method in accordance with claim 7
24 wherein said metal is selected from the group consisting
25 of steel(s), aluminum, titanium or mixtures thereof.
26

27 Claim 9. The method in accordance with claim 7
28 wherein

1 said peroxycarboxylic acids are formed from acids selected
2 from the group consisting of formic acid, acetic acid,
3 citric acid, oxalic acid, gluconic acid, glucoheptonic
4 acid, succinic acid, acrylic acid, polyacrylic acid,
5 maleic acid, polymaleic acid, polyepoxysuccinic acid,
6 ethylene-diamine-tetraacetic acid, malonic acid, adipic
7 acid, phosphonobutanepolycarboxylic acid and mixtures
8 thereof.